

City of Bellevue

**East Link Light Rail B7/C9T to
NE 2nd Portal (B7 – Revised)
Alternative**

TM02 – Design Deviations

215382/TM02

Final | June 2011

Arup North America Ltd
403 Columbia Street
Suite 220
Seattle
WA 98104
United States of America
arup.com

This report takes into account the particular
instructions and requirements of our client.

It is not intended for and should not be relied
upon by any third party and no responsibility is
undertaken to any third party.

Job number 215382-00

ARUP

Document Verification

ARUP

Job title		East Link Light Rail B7/C9T to NE 2nd Portal (B7 – Revised) Alternative		Job number		215382-00	
Document title		TM02 – Design Deviations				File reference	
Document ref		215382/TM02					
Revision	Date	Filename	TM02 – Design Deviations (Review Draft1).docx				
Review Draft 1	03/01/11	Description	Issued for review by City of Bellevue				
			Prepared by	Checked by	Approved by		
		Name	Nicholas Taylor	Richard Prust	Richard Prust		
		Signature					
Final Draft	05/3/11	Filename	TM02 – Design Deviations (Final Draft).docx				
		Description	Revised to address comments from City of Bellevue and Sound Transit.				
			Prepared by	Checked by	Approved by		
		Name	Nicholas Taylor	Richard Prust	Richard Prust		
		Signature					
Final	6/24/11	Filename	TM02 – Design Deviations (Final).docx				
		Description	Final issue.				
			Prepared by	Checked by	Approved by		
		Name	Nicholas Taylor	Richard Prust	Richard Prust		
		Signature	N.T.L.	R. Prust	R. Prust		
		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					
		Signature					

Issue Document Verification with Document



Contents

	Page
1 Executive summary	1
2 Background	2
2.1 Project description	2
2.2 Technical memo scope	3
2.3 Technical memo objectives	3
2.4 Key meetings and background documents	3
3 Methodology and data	4
3.1 Base data and information	4
3.2 Key assumptions	4
3.3 Methodology	5
4 Operations	6
5 Environmental	7
5.1 Noise and vibration	7
6 Track alignment and vehicle clearance	8
6.1 General	8
6.2 Design speed	8
6.3 Tangent alignment	10
6.3.1 Curved section of track	10
6.3.2 At station platforms	10
6.4 Curved alignment	11
6.4.1 Minimum radii for mainline tracks	11
6.4.2 Superelevation	11
6.4.3 Vertical grades	12
6.4.3.1 Mainline tracks	12
6.4.3.2 Stations	12
6.4.3.3 Yard track, pocket tracks and turnouts	12
6.4.4 Vertical tangents	13
6.4.5 Vertical curves	13
6.4.6 Vertical clearances to overhead structures	14
6.4.6.1 At overhead bridges	14
6.4.6.2 Link structures over roadways	14

7	Stations	15
7.1	A-2 Station	15
7.2	East Main Station	15
7.3	Approach to Bellevue Transit Center Station	15
8	Conclusions	16

1 Executive summary

The design of the East Link light rail system is prescribed by the requirements of the Sound Transit Design Criteria Manual. This manual describes the criteria to be adopted in all aspects of the light rail system design, including track alignment and station design.

In certain circumstances, deviation from the requirements of the Sound Transit Design Criteria Manual requires approval by Sound Transit. The summary below identifies where this approval would be required.

Design deviations which require Sound Transit approval

All design criteria have been established at conditions which do not require Sound Transit approval, except for the following. The Sound Transit Design Criteria Manual identifies that the following situations would require Sound Transit approval:

- The alternative which considers LRT and freight operations potentially sharing track in the future (BNSF corridor).
- Design deviation for 20mph running speed would be required at approximately 2054+00 if a turnout were refitted in the future to allow a future freight operator to share LRT tracks. The deviation could be avoided by reducing running speed to 15 mph. Alternatively the turnout could be placed at 2056+00, but this would require additional RoW on the east side of the corridor.

2 Background

2.1 Project description

The East Link project is an extension to Sound Transit's Link light rail system that will provide light rail service across Lake Washington, linking Seattle, Bellevue, and Redmond (Overlake).

For the segment of East Link between the Lake Washington crossing and downtown Bellevue, Sound Transit has developed the B7 alternative to a conceptual engineering level of design (approximately five percent design) as part of the Draft Environmental Impact Statement (DEIS) for the project which was issued in December 2008.

A Supplemental Draft EIS, which analyzes new alternatives developed since the DEIS, was published in November 2010. That supplemental document includes updated conceptual engineering for the Sound Transit B7 alternative and a C9T alternative that could connect B7 to a station at the Bellevue Transit Center. A Final EIS is expected in the summer of 2011.

At the September 13, 2010, Bellevue City Council Study Session, the council discussed the need for design variations and for additional analysis of revised East Link B7 and C9T alternatives. The objectives of the additional analysis would be to improve performance, to reduce impacts, and to reduce costs, as compared with the Sound Transit B7 and C9T alternatives. As a result of that discussion the council initiated the development of a modified B7 alternative ("B7-Revised"). The council directed City staff to develop an "apples-to-apples" comparison of the Sound Transit B7 and C9T alternatives with a B7-Revised alternative. Arup were commissioned by the City to develop the B7-Revised alternative.

The B7-Revised alternative begins at the transition from East Link Segment A to Segment B at the east shore of Lake Washington and connects with a new elevated station (A-2 Station) over south Bellevue Way/I-90 ramps. The alignment continues east from the station along the north side of I-90 and turns north into the BNSF corridor with an at-grade profile. The alignment transitions to elevated as it leaves the BNSF corridor, crosses over SE 8th Street, and transitions back to at-grade prior to a new station (East Main Station) just south of Main Street on the current Red Lion Hotel site. The alignment crosses under Main Street and turns west on the current Sheraton Hotel site before entering a tunnel portal at NE 2nd Street. The B7-Revised alternative is approximately three miles long with a combination of at-grade, elevated, and open-cut sections.

2.2 Technical memo scope

The scope of this memo is to identify deviations from Sound Transit’s design criteria, specifically as described in the Design Criteria Manual.

The scope of this memorandum does not include describing adopted criteria for the design. This technical memo should be read in the conjunction with the other technical memos produced for this study, in particular:

- Station Concept Report (TM03)
- Early Concept Alignment (TM06)

2.3 Technical memo objectives

The purpose of the Design Deviations Tech Memo is to document deviations from Sound Transit criteria, in particular identifying specific areas of the concept design which would require Sound Transit approval to relaxation of requirements described in the Design Criteria Manual.

2.4 Key meetings and background documents

Date	Agency/Stakeholder	Attendees
Not applicable		

Table 1 – Relevant meetings

Relevant documents and reports used to support the analysis included the following:

Document	Referred to in Technical Memo as:	Relevance to Technical Memo:
Central Puget Sound Regional Transit Authority, <i>North/South Link Design Criteria Manual, 2010</i> . Seattle, WA: Sound Transit.	DCM	Establishes design requirements for Sound Transit light rail facilities
Metro, Municipality of Metropolitan Seattle (March 1991). Metro Transportation Facility Design Guidelines. Seattle, WA: King County Metro	King County Facility Design Guidelines	Establishes design requirements for transit center and ramps

Table 2 - Relevant documents and reports

3 Methodology and data

The project team has been directed by Bellevue City Council to prepare an “apples-to-apples” comparison of the B7-Revised alignment with the Sound Transit Draft Environmental Impact Statement (DEIS) and Supplemental Draft Environmental Impact Statement (SDEIS) B7/C9T alignment. Such a comparison requires consistency of three elements – base data and information, key assumptions, and methodology. The following sections and tables outline the key aspects of the A-2 Station, how these aspects were addressed for the Sound Transit B7/C9T alignment and whether this is considered a true “Apples to Apples” comparison. Comment is made particularly for changes in approach.

3.1 Base data and information

B7-Revised	B7/C9T	“Apples-to-Apples”	Comment
Not applicable			

Table 3 - Comparison with Sound Transit DEIS and SDEIS base data and information

3.2 Key assumptions

B7-Revised	B7/C9T	“Apples-to-Apples”	Comment
Minimize/maximize preferred alignment criteria	Same	Yes	
Avoid design deviations requiring Sound Transit approval	Same	Yes	
Design deviation is required for shared track use	n/a - No shared track	No	Refer to Section 4. Shared LRT and Freight usage has been proposed to minimize the construction in the BNSF corridor
Design deviation for 20mph running speed is required for turnout at approximately STA 2054+00, if the alignment is refitted in the future to allow freight trains to connect between the light rail track and the BNSF freight corridor.	n/a - No shared track	No	Refer to Section 6.2. As a result of the super-elevation the running speed across the turnout would be reduced from 30mph to 20mph (deviation from the Sound Transit Design Criteria Manual standards would be required). Note – locating the turnout at STA 2056+00 (with additional RoW consequences), or reducing the running speed to 15mph would not require a design deviation.

Table 4 - Comparison with Sound Transit DEIS and SDEIS key assumptions

3.3 Methodology

B7-Revised	B7/C9T	“Apples-to-Apples”	Comment
Sound Transit, North/South Link Design Criteria Manual, 2010	Same	Yes	

Table 5 - Comparison with Sound Transit DEIS and SDEIS methodology

4 Operations

Section 2.6.5 of the Design Criteria Manual states:

Freight railroad vehicles Non-Revenue Vehicles (NRV's) will not be permitted to operate on Light Rail Vehicles (LRV) tracks, unless specially authorized by Sound Transit.

The shared rail B7-Revised alternative evaluated (refer to the Early Concept Alignment Technical Memo TM06) would require Sound Transit authorization. Sound Transit would consider this a significant deviation.

5 Environmental

5.1 Noise and vibration

There are no foreseen design deviations.

6 Track alignment and vehicle clearance

6.1 General

In the following sections, reference is made to design conditions and design criteria. The terminology adopted is as per the Sound Transit Design Criteria Manual Chapter 4. Tables from that chapter have not been reproduced herein.

6.2 Design speed

The desirable design speed (Sound Transit Design Criteria Manual Section) for the Sound Transit system is 55 mph, noting that physical constraints may preclude achievement of this objective. There are a number of locations where constraints to the horizontal alignment require a reduction in speed.

Design speeds for each curve are described in Table 6 overleaf.

Design Speed (mph)	Length (ft)	Begin Station	End Station	Notes
50	158	2000+00	2001+58	Following I-90 corridor and raising from central reserve to cross carriageway.
45	1172	2001+58	2013+29	
30	366	2013+29	2016+96	
55	2720	2016+96	2044+16	
30 ⁽¹⁾	1247	2044+16	2056+62	Transition from I-90 corridor to BNSF corridor. Reduced speed to minimize impact on Mercer Slough and properties.
55	4392	2056+62	2100+55	Follows BNSF corridor
50	1052	2100+55	2111+07	Parallel to I-405 into East Main Station
55	395	2111+07	2115+02	
45	747	2115+02	2122+49	
55	3698	2122+49	2159+47	
50	664	2159+47	2166+11	
20	560	2166+11	2171+71	
15	491	2171+71	2176+62	Curve into tunnel north of East Main Station and following city street grid pattern
55	594	2176+62	2182+56	

Note 1 - Section 4.4 of the early Concept Alignment technical memo (TM06) explores two alternatives for turnouts to allow freight trains to connect between the light rail track and the BNSF freight corridor. The option presented in the table above has turnouts at approximately STA 2054+00 (to connect to the south BNSF corridor), and at 2099+00 (to connect to the north BNSF corridor across I-405). The running speed across the southern turnout at STA 2054+00 would be reduced from 30mph to 20mph (deviation from the Sound Transit Design Criteria Manual standards would be required) or to 15mph (no deviation required).

Alternatively, the southern turnout could be located at 2056+00 with no requirement for a deviation from Sound Transit Design Criteria, however this would have additional RoW consequences.

Table 6 - Design speeds along the B7-Revised alternative

6.3 Tangent alignment

6.3.1 Curved section of track

Condition	Begin Station	End Station
Minimum	2000+00	2016+96
Desirable Minimum	2016+96	2098+93
Minimum	2098+93	2111+07
Desirable Minimum	2111+07	2170+70
Minimum	2170+70	2176+62
Desirable Minimum	2176+62	2182+56

Table 7 – Adopted tangent alignment conditions

A Minimum tangent alignment condition does not require approval from Sound Transit.

6.3.2 At station platforms

Condition	Location
> Desirable Minimum	A-2 Station
> Desirable Minimum	East Main Station
> Desirable Minimum	Bellevue Transit Center Station

Table 8 – Adopted tangent alignment conditions at station locations

A Minimum tangent alignment condition does not require approval from Sound Transit.

6.4 Curved alignment

6.4.1 Minimum radii for mainline tracks

Condition	Curve Radii	Begin Station	End Station	Notes
Aerial structures	> 500ft	2000+00	2016+96	Following I-90 corridor and raising from central reserve to cross carriageway
Aerial structures	> 500ft	2016+96	2044+16	Transition Structure
Aerial structures	> 500ft	2044+16	2054+00	Transition from I-90 corridor to BNSF corridor. Reduced speed to minimize impact on Mercer Slough and properties
At-grade ballasted	> 300ft	2054+00	2107+00	Follows BNSF corridor
Aerial structures	> 500ft	2107+00	2142+00	Parallel to I-405 on aerial structure
At-grade ballasted	> 250ft	2142+00	2166+11	Parallel to I-405 into East Main Station
Subway section	>250ft	2166+11	2171+71	Curve into tunnel north of East Main Station and following city street grid pattern
Subway section	250ft	2171+71	2182+56	Curve into Bellevue Transit Center Station. Minimum radius due to spatial constraints

Table 9 – Adopted curve radii

All sections of alignment are greater or equal to the minimum radii for each section condition.

6.4.2 Superelevation

Maximum Ea	Maximum Eu	Begin Station	End Station	Notes
4 in	3 in	2000+00	2182	Desirable Maximum adopted

Table 10 – Adopted superelevation condition

All sections of alignment have adopted Desirable Maximums for superelevation design criteria.

6.4.3 Vertical grades

6.4.3.1 Mainline tracks

Criteria	Criteria	Adopted design criteria
Maximum (sustained unlimited length)	4.00%	Same
Maximum (sustained grade with up to 2,500ft between PVIs of vertical curves)	6.00%	Same
Maximum (short sustained grade with no more than 500 feet between PVIs of vertical curves)	7.00%	Same
Minimum (for drainage on direct fixation track)	0.20%	Same

Table 11 - Adopted vertical grade design criteria

Minimum or Maximum vertical grade criteria have been adopted through the length of the alignment.

6.4.3.2 Stations

Condition	LRT Station	Notes
Desirable	A-2	0.5%
Desirable	East Main	0.3%
Absolute Maximum	Bellevue Transit Center	Station track at 1.4% to match previous C9T design at connection point.

Table 12 - Adopted vertical grade design criteria at station platforms

Sound Transit authorization would not be required to adopt a 1.4% grade at the Bellevue Transit Center Station. However, Sound Transit considers that there is a design risk in being at the station grade at an early stage in design.

6.4.3.3 Yard track, pocket tracks and turnouts

Not applicable.

6.4.4 Vertical tangents

Condition	Begin Station	End Station	Notes
Desirable Minimum	2000+00	2033+58	
Minimum	2033+58	2034+94	Below Desirable Minimum as length is 59ft. Above Design Criteria Minimum of 40ft.
Desirable Minimum	2034+94	2184+80	

Table 13 - Vertical tangent design conditions

A Minimum tangent alignment condition does not require approval from Sound Transit.

6.4.5 Vertical curves

Condition	Begin Station	End Station	Notes
Preferred Minimum	2000+00	2182+28	Both Sag Curve and Crest Curves
< Preferred Minimum, > Absolute Minimum	2182+28	2186+78	To allow tie-in to previous C9T design levels at Bellevue Transit Center.
Preferred Minimum	2186+78	2182+56	

Table 14 - Vertical curve design conditions

A Preferred Minimum vertical curve condition does not require approval from Sound Transit.

6.4.6 Vertical clearances to overhead structures

6.4.6.1 At overhead bridges

Condition	Crossing	Station	Notes
> Preferred minimum	Main Street	2160+00	Approx 30ft between top of rail and FSL of Main Street. Assuming a structural thickness between 6ft and 8ft, the condition will be above the Preferred Minimum.
Desired minimum	Intersection of NE 2 nd St & 112 th Ave NE	2168+75	Approx 25ft between top of rail and FSL of 112 th Ave NE. Assuming a structural thickness between 6ft and 8ft, the condition will likely be between Desired and Preferred Minimum.

Table 15 - Vertical clearance design conditions to overbridges

A Preferred Minimum condition does not require approval from Sound Transit.

6.4.6.2 Link structures over roadways

Condition	Crossing	End Station
> Desired minimum	I-90 WB	2017+00
> Desired minimum	I-90 On Ramp	2021+50
> Desired minimum	I-90 On Ramp	2023+00
> Desired minimum	I-90 Off Ramp	2024+00
> Desired minimum	I-90 Off Ramp	2028+00
> Desired minimum	118 th Avenue SE	2046+75
> Desired minimum	SE 32 nd Street	2053+50
> Desired minimum	118 th Avenue SE	2121+25
> Desired minimum	118 th Avenue SE	2126+00
> Desired minimum	I-405 SB On Ramp	2130+00
> Desired minimum	SE 8 th Street	2131+50
> Desired minimum	114 th Avenue SE	2137+50
> Desired minimum	SE 6 th Street	2138+75

Note 1 – The clearance from finished ground to top of rail over 112th Avenue NE on NE 6th Street is about 26.3 ft consistent with the previous C9T design provided to the project team.

Table 16 - Vertical clearance design conditions over roadways

All bridge crossings are above the Desired Minimum condition. This does not require approval from Sound Transit.

7 Stations

7.1 A-2 Station

There are no foreseen Sound Transit design deviations for A-2 Station/ Park-and-Ride.

The Sound Transit Design Criteria Manual does not stipulate maximum climbing grades for bus access to station or park-and-ride facilities. Reference has instead been made to King County Metro transit facility guidelines, which state that “loaded buses are severely affected on grades steeper than 6 or 7 percent”. The access ramp to the transit center is at this maximum.

From N-W corner of parking structure to the top of the escalator on the platform is a distance of 1,300ft, this would equate to a 5.4 minute walktime at 4ft/sec walkspeed. So with elevator time, it would be around 6 minutes.

For comparison from the South-west corner of the structure to the top of escalator on the platform it would be 1,000ft with a walktime of 4.2 minutes with elevator time this would be around 4.75 minutes.

The Sound Transit Design Criteria Manual does not stipulate a maximum walk distance, and places Park-and-Ride walk convenience at the bottom of a hierarchy of optimization for other access modes to light rail stations. King County Metro Design Standards state that bus patrons are to have a maximum walk of 300 to 400 feet.

7.2 East Main Station

There are no foreseen design deviations for East Main Station.

7.3 Approach to Bellevue Transit Center Station

There are no foreseen design deviations for the approach to Bellevue Transit Center Station.

8 Conclusions

All design criteria have been established at, or better than, conditions which do not require Sound Transit approval, except for the following. The Sound Transit Design Criteria Manual identifies that these would require Sound Transit approval:

- The shared rail B7-Revised alternative evaluated (refer to the Early Concept Alignment Technical Memo) would require Sound Transit authorization.
- Park-and-Ride walk distance at the A-2 Station exceeds King County Metro Design Standards.